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Introduction

Differences between reciprocal crosses are the result of breed differences in prenatal maternal effects and/or breed differences in postnatal maternal effects. Breed differences in postnatal maternal effects are well documented and are mediated through breed differences in milk production and perhaps through other maternal factors. Breed differences in prenatal maternal effects have received less attention by research interests than breed differences in postnatal maternal effects. Breed differences in prenatal maternal effects may be caused by either differences in ovum cytoplasm or by differences in uterine environment or by both. In most reports of experimental results, the prenatal and postnatal components of maternal effects have been confounded, as is the case for the results reported here.

Procedure

This study included 1,207 calves born (625 males and 582 females) in 1973 and 1974 as a result of mating Hereford, Angus, Red Poll, and Brown Swiss females by artificial insemination to Hereford, Angus, Red Poll, and Brown Swiss sires (Table 1).

The Hereford and Angus dams used in this experiment were sampled as calves from commercial producers in western Nebraska. Brown Swiss dams were either purchased as calves from dairy farms in Wisconsin, Iowa, and Minnesota or produced at the U.S. Meat Animal Research Center (MARC). Most of the Brown Swiss dams were of domestic ancestry; however, some were by a Brown Swiss sire imported from Switzerland. Red Poll dams in this experiment were registered purebreds that were either purchased as calves from breeders in Missouri, Illinois, Indiana, Wisconsin, and Texas or produced at MARC. All breed groups of females ranged in age from 4 to 9 years when their progeny were born in 1973 and 1974.

Most sires of each breed were used both years. Hereford, Polled Hereford, Angus, and four domestic Brown Swiss sires used in this study were sampled from among those selected on individual performance data as a basis for entry into the progeny testing programs of commercial AI organizations. Seven Brown Swiss sires had been imported from Switzerland and Germany (dual-purpose), and two Brown Swiss sires were from domestic Brown Swiss dams and by imported Brown Swiss sires. Red Poll sires were sampled from Red Poll breeders in the north central and southern regions of the U.S., with the objective of obtaining a representative sample of the breed. All of these Red Poll sires were being used in purebred Red Poll herds after evaluation for growth rate in the Record of Performance Program of the American Red Poll Association. Progeny test results were not available on any of the sires from any breed at the time they were sampled for use in this program. Dams of each breed were assigned at random to breed of sire and to sires within breed each year of the experiment.

The dams were maintained on improved pasture (April to November) and fed grass and legume hay on pasture during the winter. Calves were born over a 50-day calving season from early March until late April. Average birth date was April 3. All calves were identified and weighed, and male calves were castrated within 24 h of birth. Calves were creep fed whole oats from mid-August until weaning in 1973 and from early August until weaning in 1974. The average amount of creep feed consumed was 46 lb/calf in 1973 and 139 lb/calf in 1974. The calves were weaned October 23 in 1973 at an average age of 203 days. Because of drought conditions, calves were weaned September 17 in 1974 at an average age of 167 days. Creep feed consumption was probably increased in 1974 to compensate for limitations on forage availability.

Females born in both years were mated by artificial insemination (AI) for 42 days, starting May 20 for heifers born in 1973 and May 19 for those born in 1974, followed by a 22-day period of natural service mating. Females born in 1973 were moved from improved cool-season pasture to improved warm-season pasture at the end of the 42-day AI season, and the females born in 1974 were moved from improved cool-season pasture to improved warm-season pasture midway through the AI breeding period. The females were run as one herd except during the 22-day period of natural service mating after the 42-day AI breeding season when they were run in two herds. In both years, the females remained on improved warm-season pasture until October.

In both years, females were weighed at about 28-day intervals from weaning until they were turned on to improved cool-season pasture. The females were weighed at the end of the natural service breeding season at an average age of about 470 days and again on September 30 for the heifers born in 1973 and on October 6 for those born in 1974 when they were palpated for pregnancy and measured for hip height at an average age of about 550 days.

The steers produced in 1973 were slaughtered serially at average ages of 423, 451, and 485 days for an average slaughter age of 453 days for all steers. The steers produced in 1974 were slaughtered serially at average ages of 421, 449, and 485 days for an average slaughter age of 452 days for all steers. Steers were assigned to slaughter schedule at random within breeding group. About one-third of each breeding group on which carcass data were analyzed were slaughtered at each date in the serial slaughter schedule for each year.

The steers were weighed without shrink and transported to a commercial cattle abattoir where they were slaughtered and chilled by standard procedures. The carcass data were obtained after a chill period of about 24 h. Standard procedures were used to obtain objective measures and in subjective evaluations of the traits for which data were collected and analyzed.

Multiple regression equations were used to estimate cutability (pct), retail product (pct), retail product weight (lb), fat trim (lb) and bone (lb).

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Table 1.—Experimental design showing number of calves produced by subgroup

	Sires and number of offspring									
	Red Poll		Brown Swiss		Hereford		Angus		Total	
Dams	Born	Weaned	Born	Weaned	Born	Weaned	Born	Weaned	Born	Weaned
Red Poll	39	37	45	41	46	41	48	47	178	166
Brown Swiss	21	19	33	26	28	27	30	29	112	101
Hereford	93	89	123	121	86	83	103	99	405	392
Angus	121	119	139	133	126	123	126	117	512	492
Total	274	264	340	321	286	274	307	292	1,207	1,151

Results

Differences between reciprocal crosses are presented in Table 2 for preweaning traits, in Table 3 for growth rate and puberty of females, in Table 4 for growth traits of steers, and in Table 5 for carcass traits of steers. Differences between reciprocal crosses of two breeds include prenatal and postnatal maternal effects as well as any differences in average additive direct genetic effects between the sample of sires and of dams represented in the reciprocal crosses (e.g., H♂ x A♀ *vs* A♂ x H♀).

Calves with Angus dams in crosses with Hereford and calves with Brown Swiss dams in crosses with Red Poll did not differ from reciprocal crosses in birth weight but gained significantly faster preweaning and were significantly heavier at weaning. Calves with Angus dams in crosses with Hereford and calves with Brown Swiss dams in crosses with Red Poll gained at a slower rate postweaning than reciprocal crosses of both sexes so that little or no difference was observed between these reciprocal crosses in 550-day weight of females, 424-day weight of steers and slaughter weight, carcass weight, estimated retail product weight, estimated fat trim weight, and estimated bone weight of steers. Thus, calves with Hereford dams in crosses with Angus and calves with Red Poll dams in crosses with Brown Swiss compensated during the postweaning period for their slower growth rate than reciprocal crosses during the preweaning period (Tables 2, 3, 4, and 5).

Generally, calves with Red Poll and Brown Swiss dams in crosses with Hereford and Angus were heavier than reciprocal crosses at birth and at weaning and in weights and heights postweaning; steers had heavier slaughter weight, carcass weight, estimated retail product weight, estimated fat trim weight, and estimated bone weight (Tables 2, 3, 4, and 5). Calves with Red Poll and Brown Swiss dams in crosses with Hereford and Angus had postweaning gains that averaged approximately the same as gains of the reciprocal crosses. For females, the reciprocal difference involving these crosses averaged 74 lb at weaning and averaged 61 lb at 550 days; for steers, the reciprocal difference involving these crosses averaged 78 lb at weaning, 84 lb at 424 days, and 81 lb at slaughter (453 days) and produced carcasses that were 49 lb heavier. Thus, there was no weight gain compensation for calves with Red Poll and Brown Swiss dams in crosses with Hereford and Angus during the postweaning period; the magnitude of the difference in favor of the reciprocal crosses with Red Poll and Brown Swiss dams in crosses with Hereford and Angus was approximately the same at yearling age as at weaning.

The lack of difference in composition of gain between the reciprocal crosses with Red Poll and Brown Swiss dams in crosses with Hereford and Angus is reflected by no difference between these reciprocal crosses in estimated cutability (pct) and estimated retail product (pct, Table 5). Thus, the weight increase in favor of the reciprocal cross steers with Red Poll and Brown Swiss dams in crosses with Hereford and Angus was proportional in regard to lean, fat, and bone tissue.

Table 2.—Differences between reciprocal crosses - preweaning traits

Reciprocal crosses[a]	Birth weight (lb)	Calving difficulty (pct)	Calf crop weaned (pct)	Average daily gain (lb)	200-day weight (lb)
BR minus RB	1.3	19.8**	.7	−.16**	−31**
HR minus RH	2.9	7.9	−6.3	.26**	55**
AR minus RA	5.3**	1.7	.3	.24**	52**
HB minus BH	8.8**	−12.8*	−1.9	.50**	110**
AB minus BA	4.4*	−5.4	1.1	.43**	90**
AH minus HA	−.9	−1.6	−1.6	−.12**	−26**

[a]R = Red Poll, B = Brown Swiss, H = Hereford, A = Angus. Sire breed listed first.
*P <.05.
**P<.01.

These results show that increased weight gains associated with maternal effects during the prenatal and the postnatal preweaning periods and reflected at slaughter do not have the same effect on composition of the increased weight gain as does a higher nutritive environment provided during the growing-finishing period through increased dietary energy density. Results from research conducted at MARC have shown that increasing the dietary energy density beyond 2.6 to 2.7 Mcal ME/kg during the growing-finishing period will result in increased weight gain but that more than 80 percent of the increased weight gain is the result of increased carcass fatness. Thus, it is concluded that either the nutritive environment associated with maternal effects (prenatal and postnatal) has an influence on composition of increased weight gain different from that of the nutritive environment associated with growing-finishing dietary regimen, or that the effect of dietary regimen on composition of increased weight gains may be different if administered before the growing-finishing period.

These results show that the maternal effect on growth rate for some breed crosses starts prenatally and is reflected by increased birth weight (Table 2), is accelerated during the preweaning period, and is of about the same magnitude at yearling as at weaning (Tables 2, 3, and 4). Prenatal and postnatal maternal effects and their persistence, at least to yearling age, are particularly relevant in considering breed of recipient effects on calves produced by embryo transfer.

These results suggest that breeds that have been selected for milk production (Red Poll and Brown Swiss) in crosses with breeds that have not been selected for milk production (Hereford and Angus) show maternal effects of a different nature in regard to prenatal growth rate and postweaning compensation for differences in preweaning growth rate than do reciprocal crosses among breeds where selection criteria for milk production have been similar; e.g., Red Poll with Brown Swiss or Hereford with Angus. The biological basis for this interesting phenomenon is not apparent.

Table 3.—Differences between reciprocal crosses - growth rate and puberty in females

Reciprocal crosses[a]	200-day weight (lb)	400-day weight (lb)	500-day weight (lb)	550-day hip height (in)	Weight at puberty (lb)	Age at puberty (days)	Pregnant 550 days (pct)
BR minus RB	−43*	−32	−10	−.51	−14	17	12
HR minus RH	56**	63**	45**	.28	60**	2	−5
AR minus RA	50**	52**	58**	.79**	58**	11	2
HB minus BH	102**	89**	71**	1.06**	53**	−26*	−5
AB minus BA	86**	73**	71**	1.38**	42**	−27*	−10
AH minus HA	−36**	−28*	0	.47	4	22*	18

[a]R = Red Poll, B = Brown Swiss, H = Hereford, A = Angus. Sire breed listed first.
*P<.05.
**P<.01.

MARC has an experiment in progress to determine, by use of embryo transfer involving reciprocal crosses of the Brown Swiss and Hereford breeds and reciprocal crosses of the Red Poll and Angus breeds, the relative contribution of differences in ovum cytoplasm and differences in uterine environment in contributing to prenatal maternal effects. Further, the relative contribution of prenatal and postnatal maternal effects to total maternal effects are being determined by early weaning one-half of the calves from these matings and allowing the other one-half of the calves to remain on their dams to an age of about six months. The results from the experiment reported here stimulated the interest to conduct the experiment to determine the relative contribution of prenatal and postnatal factors to total maternal effects and to determine the relative contribution of ovum cytoplasm and uterine environment in contributing to prenatal maternal effects.

Table 4.—Differences between reciprocal crosses - growth traits of steers

Reciprocal crosses[a]	200-day weight (lb)	312-day weight (lb)	424-day weight (lb)
BR minus RB	−23	−6	17
HR minus RH	52**	56**	56**
AR minus RA	56**	74**	86**
HB minus BH	111**	111**	70**
AB minus BA	92**	86**	125**
AH minus HA	−14	−10	12

[a]R = Red Poll, B = Brown Swiss, H = Hereford, A = Angus. Sire breed listed first.
**P<.01.

Table 5.—Differences between reciprocal crosses - carcass traits of steers

Reciprocal crosses[a]	Slaughter weight, 453 days (lb)	Carcass weight (lb)	Est. cut.[b] (pct)	Est.[b] retail product (pct)	Est.[b] retail product (lb)	Est.[b] fat trim (lb)	Est.[b] bone (lb)
BR minus RB	42	19	1.3	1.5	21	2	2
HR minus RH	52**	32**	−.6	−.7	15	9*	4**
AR minus RA	76**	48**	−.8	−1.0	23**	14**	5**
HB minus BH	75**	51**	−.4	−.4	28**	10*	6**
AB minus BA	121**	65**	−.7	−.9	35**	16**	8**
AH minus HA	21	6	−.1	−.2	3	2	0

[a]R = Red Poll, B = Brown Swiss, H = Hereford, A = Angus. Sire breed listed first.
[b]Est. = estimated; cut. = cutability.
*P<.05.
**P<.01.